PROPOSED OBSERVATIONS OF THE MARTIAN ATMOSPHERE

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1. Introduction

At a joint session of the 1958 Annual Meetings of the Institute of Aeronautical Sciences and the American Meteorological Society a paper was presented, and subsequently published,[1] as a detailed report of Navy manned balloon flight designated Strato-Lab High #2. That paper also reviewed the Strato-Lab program and discussed the capability of the manned balloon for research related to the exploration of space. As a specific example measurements of the Martian atmosphere proposed by Professor John Strong of the Johns Hopkins University, Baltimore, Maryland, were described in a general fashion.

When this paper was requested by personnel of the Vitro Laboratories, it was envisioned initially that it would be a flight report of the first stratospheric attempt by people to make an atmospheric measurement of the planet Mars. Unfortunately, due to failure of the balloon during inflation, the planned observation has been postponed. In view of this a brief status report of this phase of the program will be presented and an indication of the future.

2. Background of Proposed Strato-Lab Observations of Mars

Professor Strong's proposal for Strato-Lab research specified an initial objective would be a spectrographic analysis of the planetary atmosphere of Mars. Experimentally, during two separate flights, he proposed to determine the content of water vapor and oxygen. When his proposal was accepted for joint support by the Office of Naval Research and the National Science Foundation, his preliminary system design advanced to a detailed design study and was soon followed by a developmental phase. In parallel with the Johns Hopkins University effort the Office of Naval Research contracted with Winzen Research Incorporated, Minneapolis, Minnesota, to integrate the ultimate "Strong" system with the Strato-Lab gondola, make tests and system changes necessary for successful conduct of the experimental flights, provide balloons and associated equipment, and launch the flights desired.

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Early in 1958, therefore, Winzen Research Incorporated was working on engineering problems related to integration of the complete system and the operational aspects of the first flight which was scheduled for November 1958. The Johns Hopkins University and its subcontractors had frozen most design aspects and were engaged in the development of components. The able companies associated with the Johns Hopkins University, and their areas of responsibility, were: Ferson Optical Company, Incorporated, Ocean Springs, Mississippi, development of the Schmidt reflecting telescope with a 16-inch primary mirror; Librascope, Incorporated, Glendale, California, development of an ingenious star tracker for use in initial manual acquisition of the Mars image, then "lock on" with automatic tracking; and the Farrand Optical Company Inc., New York 70, New York, which built the special Ebert type spectrograph. The latter employs four large gratings which were ruled on machines at the Johns Hopkins University.

It was apparent, however, that there were numerous areas of uncertainty. Photographic plates to record the data, for instance, were eventually replaced with a photomultiplier system which was sensitive in the infrared region of the spectrum. Other areas needed flight evaluation to determine the complete compatibility of the balloon system and Professor Strong's equipment for the November flight. Strato-Lab High #3, therefore, was conducted on 26-27 July 1958 as a system test.

3. Areas Investigated on Strato-Lab High #3

Of secondary importance there were a number of measurements and experiments conducted which were unrelated to the Strong system. Of primary importance were the tests and evaluations conducted which were directly related to determination of feasibility of the system for use by Professor Strong and his instrumentation. In outline form these general areas are listed:

a. Gondola Environment
   (1) Insulation-determine if temperature range is adequate for flight at night,
   (2) atmosphere-determine comfort of personnel through use of sea level atmospheric pressure, adequacy of air regeneration techniques to control moisture and CO2, and
   (3) use of pressure suits-make modified use of partial pressure suits to achieve comfort at altitude by removal of helmet and associated components.

b. Gondola Stability
   (1) Rigging and suspension-determine adequacy of multi-point suspension and new rigging to accommodate telescope, and
   (2) motions-obtain quantitative information regarding actual rotation and swing of gondola to determine adequacy of system.

c. Operational Aspects

(1) Balloon control-test adequacy of available ballast to maintain level flight during night,
(2) Balloon vehicle- conduct another flight test of WRI $2x10^6$ $ft.^3$ balloon with a very heavy load, and
(3) Launch and recovery-demonstrate capability to launch, track and recover a long duration flight.

A comprehensive report[2] of Strato-Lab High #3 will soon be issued by the flight contractor. In addition two papers have been presented [3,4] which have treated specific areas of interest. In summary, however, here are flight results which were pertinent to the Strong system:

a. Gondola Environment-the system changes, made as a result of personnel discomfort on Strato-Lab High #2, were quite satisfactory. Since the flight duration was 34 hours and 40 minutes, it was believed the test was rigorous and adequate.
b. Gondola Stability-analysis of the film records obtained by the Johns Hopkins University star camera were quite disappointing because of the character and rate of motions detected,
c. Operational aspects-control of the balloon for level flight after sunset was inadequate due to an electronic failure which prevented the use of battery ballast. Although the balloon vehicle performed satisfactorily it was determined during the flight that the load (over 3500 pounds) was not to be exceeded because of a visible stress concentration. It was also recognized that certain techniques and components related to the launch and landing of the aerostat could be improved substantially.

4. Considerations and System Changes

A. Gondola Environment-in this area no major changes were required because of the personnel comfort enjoyed during flight. One minor engineering modification was required to assure no spillage of the highly caustic chemical residue on landing.
b. Gondola Stability- a large amount of attention was devoted to this area because of the motions recorded, It was believed, however, that the inability to discharge proper ballast when desired (so that the balloon slowly descended 10,000 feet, then slowly reached ceiling altitude again), and deliberate motions of the personnel inside accounted for most of the instability noted. Indeed, during late night when the balloon was back at floating altitude and the personnel were sleeping, motions were recorded which were compatible with the Strong system. This area of investigations was headed by

Dr S. G. Reed, Jr., of the Office of Naval Research, and Mr. Jarus Quinn, consultant to Winzen Research. The motions were analyzed and model balloon tests conducted to acquire additional information. In a test of the complete gondola suspended in the Hippodrome of the Minnesota State Fairgrounds the natural rotational period of the gondola was determined. It was also discovered that a rather high frequency "squiggle" motion recorded was not real. The camera had been mounted on the gondola undercarriage, which was not a fixed part of the gondola, and the disturbing motions came from this and the floor inside. The major change was to introduce steel cables for the lower portion of the suspension system. Power requirements were reviewed and, through a combination of silvercell and lead storage batteries, the amount of available "dribble" ballast was increased.

(c) Operational Aspects-it was recognized that greater attention must be given to the meteorological forecast situation. Load reduction on the balloon was also considered highly desirable (when ready for flight the load was 3249 pounds). Use of the Stratobowl near Rapid City, South Dakota, would allow greater maneuverability than the confined iron mine at Crosby, Minnesota.

5. Preparation for Launch

The telescope system arrived from Baltimore mounted in a trailer. This allowed the complete system to be checked out and tested in a physical arrangement which allowed access for changes prior to installation in the gondola. Professor Strong and his scientific teams solved several problems which arose and were delighted with the tests they ran on their equipment.

Transfer of the delicate optical system from the trailer to the gondola was accomplished with a large crane made available by the nearby Ellsworth Air Force Base. Soon after the transfer was made the Johns Hopkins University personnel made necessary adjustments to their equipment, installation of control boxes was accomplished by Winzen personnel, and flight day began to draw closer.

The weather was not fully cooperative. One of the meteorological surprises was the direction of the stratospheric winds at the planned floating altitude of about 82,000 feet. Instead of the normal winter time west winds the Stratobowl (and most of the country) was under the influence of a quirk by Nature which resulted in easterly winds above 70,000 feet during most of November. East winds at altitude of course, would take the balloon toward the Rocky Mountains which were west of the Stratobowl.

The period of waiting allowed time for excellent tests of the gondola system and complete tests of the telescope system. Confidence in ultimate experimental success increased with each test. One test, in particular, was a reasonable simulation of the flight situation. During this test the gondola was suspended from the crane and swinging on the steel cable supports. On the particular night of this test (18 November) it was quite windy in the Stratobowl. Even though the gondola rotated and oscillated considerably because of the wind, there was no difficulty in making acquisition of Mars, then shifting to automatic control with the fantastically accurate (1 second of arc) Librascope star tracker, and obtaining spectra.

The signal-to-noise ratio of the system was also better than anticipated. It was this fact which would have allowed success up to the first of December or later.

Finally, after deciding to modify the flight profile and "ride" the strong westerly winds between 30,000 and 70,000 feet on descent to assure a trajectory toward the east and a favorable landing area, marginal meteorological conditions prevailed on 26 November.

Prior to inflation a delay was encountered due to a faulty microswitch in one of the two valves on top of the balloon. Aside from this, and a slight wind which gave initial trouble during inflation, everything appeared satisfactory. Dr. Strong and I entered the gondola about 15 minutes before inflation of the balloon was to be completed. We were well along on our preflight check list when we received the news that the balloon had ruptured and we got out.

The total gross inflation, including balloon, gondola, and free lift, was to have been 5000 pounds. At the time of rupture the total inflation was 4100 pounds, considerably less than the 5500 pound gross inflation of Strato-Lab High #3.

The failure was determined to be a split in the material of some 40 feet or more in length at the top of the balloon and was immediately adjacent to a heat sealed seam. Other than a possible correlation with the cold temperature in the Stratobowl (about 10F) cause of the failure was unknown.

Because of the unknown reason(s) for the failure Captain L. P. Pressler, USN, Scientific Officer, decided to postpone the flight until an objective analysis of the balloon could be made.

6. Evaluation of Balloon Failure

Although balloon post-mortems are seldom conclusive the balloon which split at Rapid City has been subjected to three independent tests and as much data as feasible collected. Tests were conducted by General Mills, Inc., Minneapolis, Winzen Research Inc., and the Visking Corporation, Chicago.

Results of the tests indicated that the material, itself was comparable to other polyethylene used for balloons and met military specifications.

Conclusions regarding the failure indicate that a combination of factors probably contributed. The ambient cold temperature causes a degradation in the capability of the material to resist tear propagation. The heat seals in the balloon were weak, only about 70% of material strength, and tensile tests indicate a marked tendency for failure along the same edge of the seal as in the balloon which failed. Unknown factors are transient lateral stresses which occurred during the heavy load inflation. One cannot overlook the fact that this same balloon type has been successfully flown with heavier loads in warm weather. Thus the correlation with low temperatures seems important.

7. Future Use of the Strong System

Although Professor Strong has not been consulted on this point it appears there are two types of experiments within the capability of his equipment. One type of measurement would be daytime use for investigation of the solar spectrum in a region of the infrared where data are lacking. The second type are the Martian atmosphere measurements and similar planetary or lunar observations which must be conducted at night.

For the daytime measurements it should be possible to combine an overall reduction in the load (no requirement for sunset ballast), with summertime warm temperature. An incremental improvement in balloon manufacture (improved seal strength) and a modest series of tests could result in an early flight for solar work.

To assure a satisfactory heavy load balloon, capable of night observations and cold temperature inflations, however, it appears that a developmental program is required. A heavy load balloon is not presently available to satisfy the stringent requirements.

8. Conclusions

In parallel with the current investigation by the Vitro Laboratories it appears that a fundamental approach must be initiated to assure that appropriate balloon vehicles are available. This must be approached in an objective manner on a long range basis.

The manned high altitute balloon has not yet been demonstrated as feasible for precise astronomical and astrophysical measurements. Based on the experience of the Strato-Lab program, however, it is my opinion that investigations of this nature are not only feasible but that the future holds great promise for the manned balloon in extra-terrestrial observations.

It is hoped that the excellent system devised by Progessor Strong will demonstrate this feasibility in the very near future.

9. References

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